

Status of MODIS and VIIRS Instrument Performance

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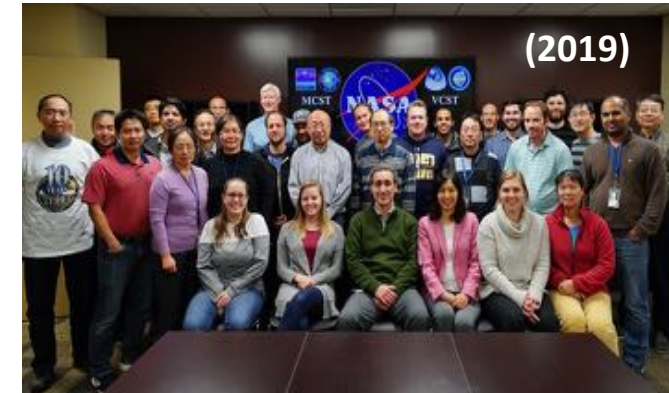
Acknowledgements

Contributions:

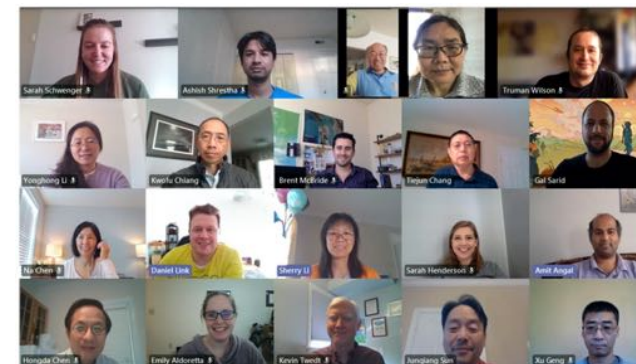
- MODIS Characterization Support Team (MCST)
- VIIRS Characterization Support Team (VCST)

Support:

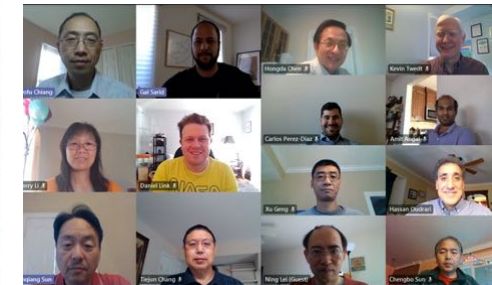
- Terra, Aqua, S-NPP, JPSS Project
- Mission/Flight Operation Teams (MOT/FOT)
- MODIS and VIIRS Science Teams
- MODIS and VIIRS Instrument Vendor (Raytheon)
- NOAA JPSS Program and VIIRS SDR Team



MCST



VCST



TEAMS on November 16, 2020

Outline

- **Instrument Status**
 - Terra and Aqua MODIS
 - S-NPP and N20 VIIRS
- **MODIS and VIIRS Calibration and Performance**
 - More Performance Examples in Backup Slides
- **Current and Future Activities**
- **Summary**

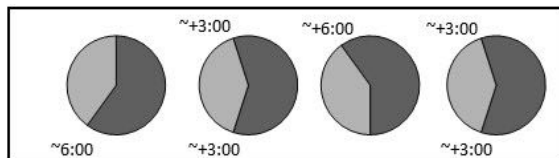


JPSS-2/3/4 VIIRS

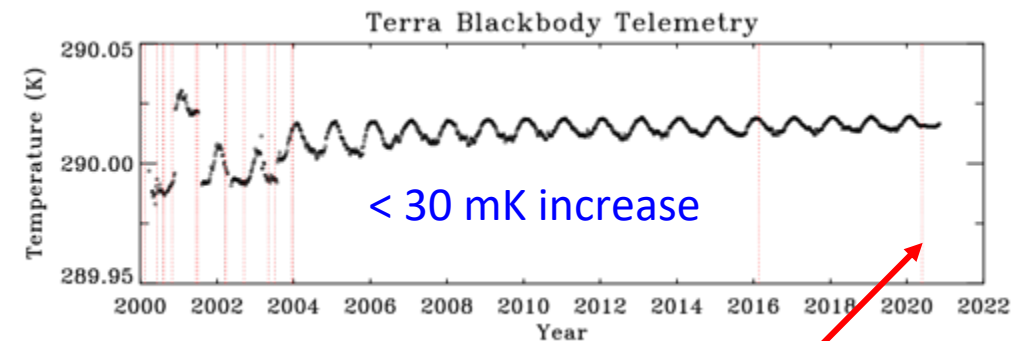
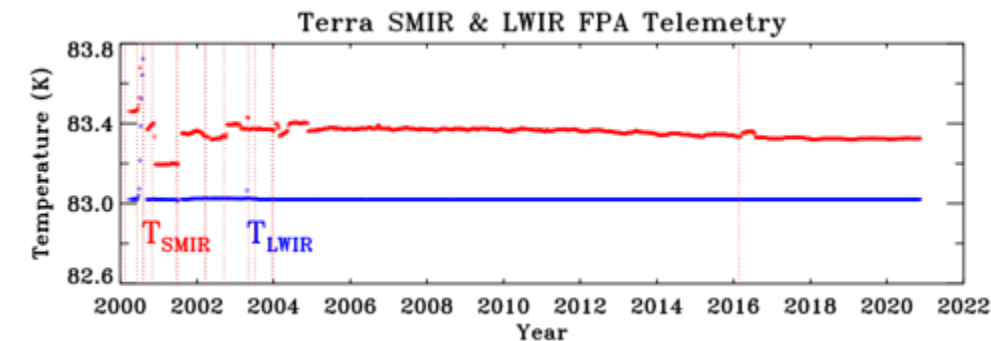
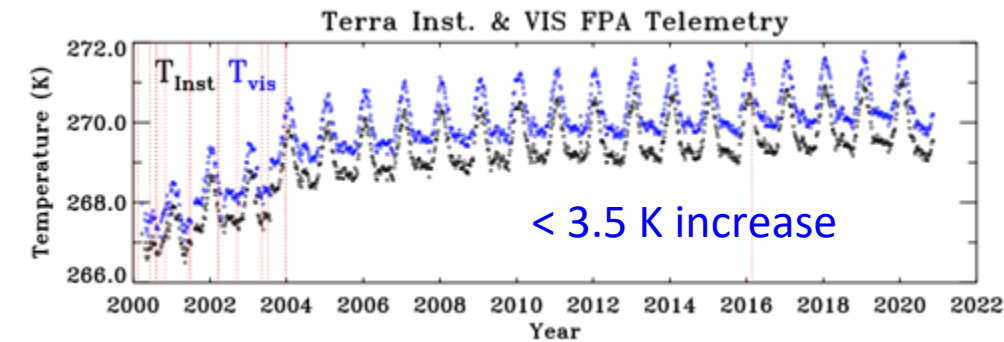
Instrument Status: Terra MODIS

Instrument Operations and OBC Functions – Normal

- Same configuration (A-side electronics with B-side formatter) since 2003
- No new noisy or inoperable detectors since last STM
 - Currently 39 noisy detectors (30 from prelaunch; 35 at-launch) and 1 inoperable detector (D6 in B29)
- Change of BB temperature setting from 290 K to 285 K, starting from April 25, 2020
- A S/C printed wire assembly (PWA) failure on Oct 05, 2020 (*see Kurt Thome's presentation*)
 - MODIS data rate changed from 50/50 (day/night) to 44.2/55.8 (starting from Oct 06, 2020)
 - A short-term schedule (STS) file generation procedure implemented to collect data over the poles from alternating orbits (starting from Nov 08, 2020)



explore feasibility for additional coverage

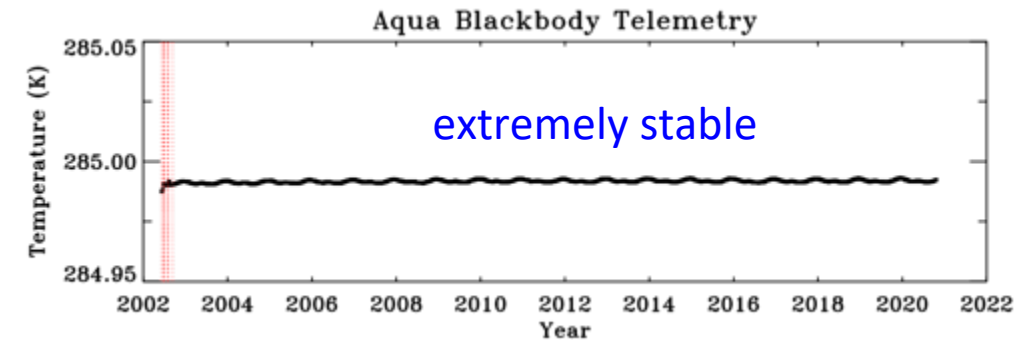
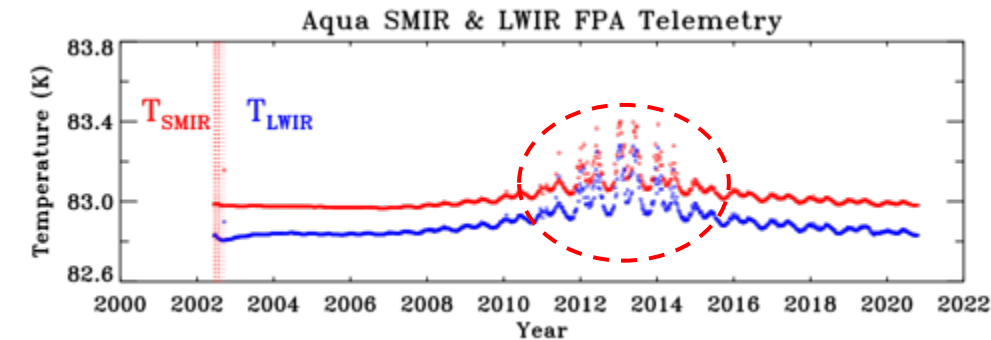
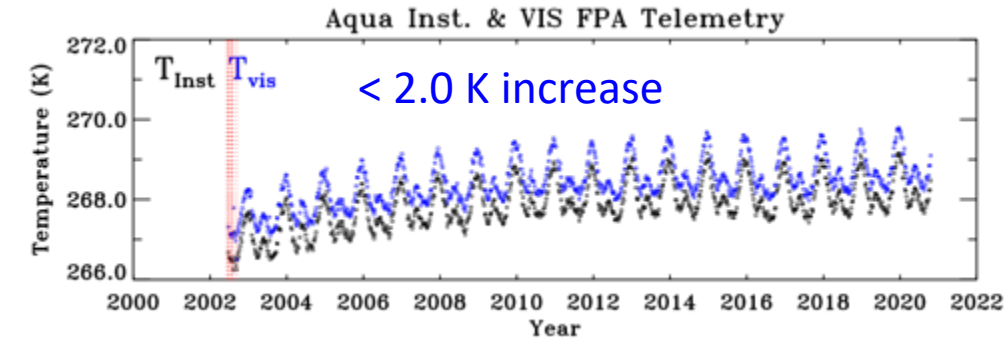


5 K added to T_BB after setting at 285 K (04/25/20)

Instrument Status: Aqua MODIS

Instrument Operations and OBC Functions – Normal

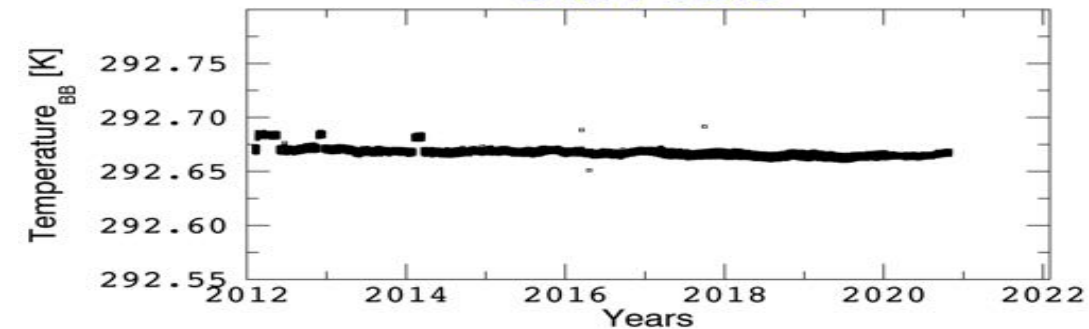
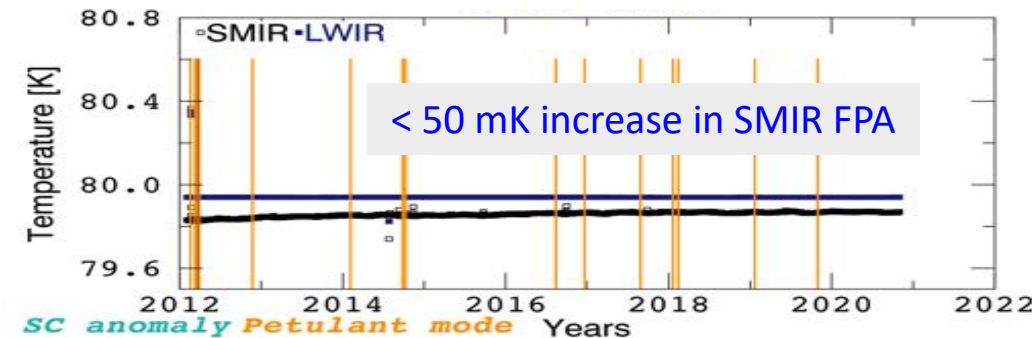
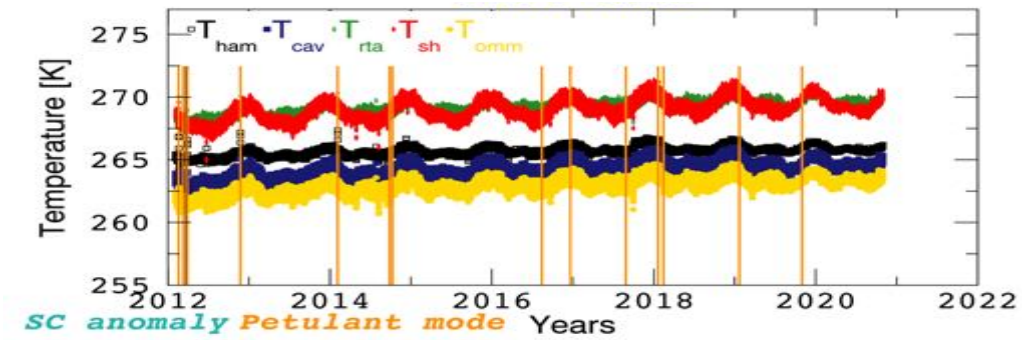
- Same B-side configuration (electronics and formatter) since launch
- No new noisy or inoperable detectors since last STM
 - Currently 10 noisy detectors (2 from pre-launch; 3 at launch) and 15 inoperable detectors (13 in Band 6)
- BB nominal temperature at 285 K – extremely stable
- Improved control of Aqua MODIS CPFA temperatures
- Aqua spacecraft FMU (formatter multiplexer unit) anomaly Aug 16, 2020; recovered for science operation Sept 02, 2020 (*see Claire Parkinson's presentation*)
 - MODIS briefly transitioned to standby mode
 - No impact on instrument health and calibration performance.



Instrument Status: S-NPP VIIRS

Instrument Operations and OBC Functions – Normal

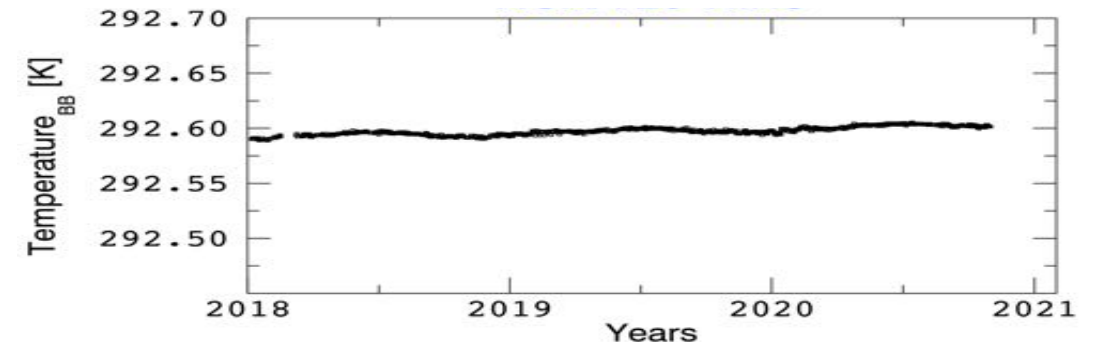
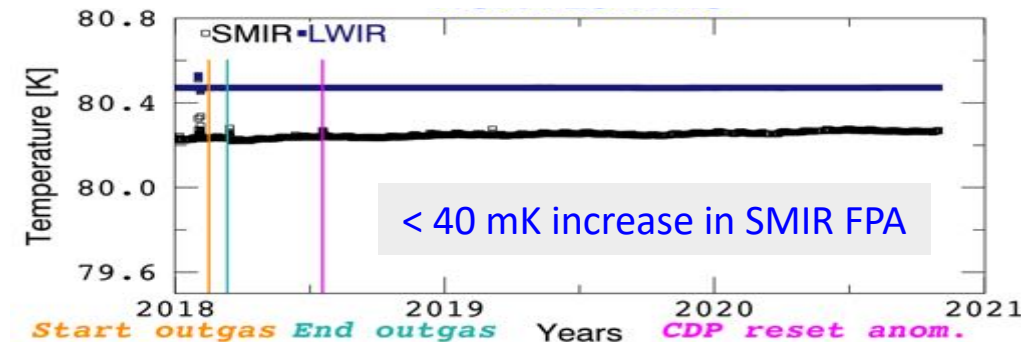
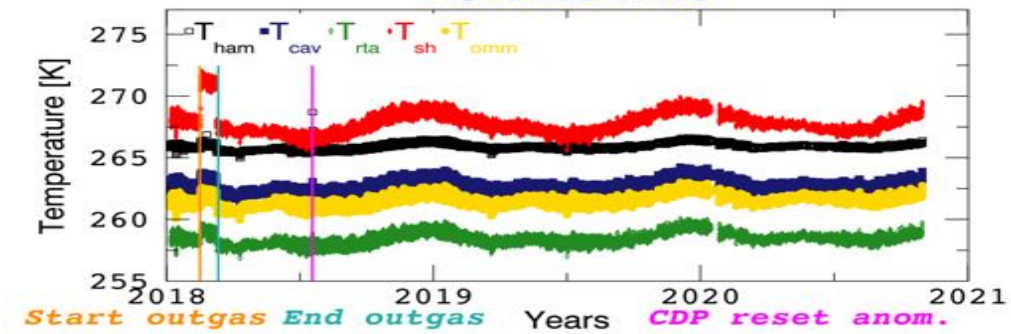
- No changes to instrument operational configuration since launch (B-side)
- No new noisy or inoperable detectors since launch
 - All detectors continue to function well
- Single Board Computer (SBC) Lock-up (petulant mode): 15 since launch (0 since last STM)
- Scan Sync Loss between RTA and HAM: 114 since launch (8 since last STM)
- Change in DNB HGB electronics following FSW x4018 upload on Jan 8 2020 => DN0/Gains LUTs update



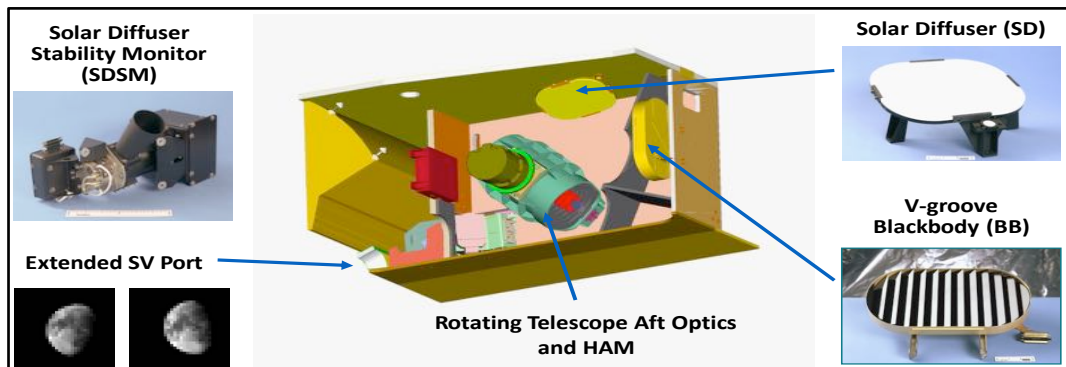
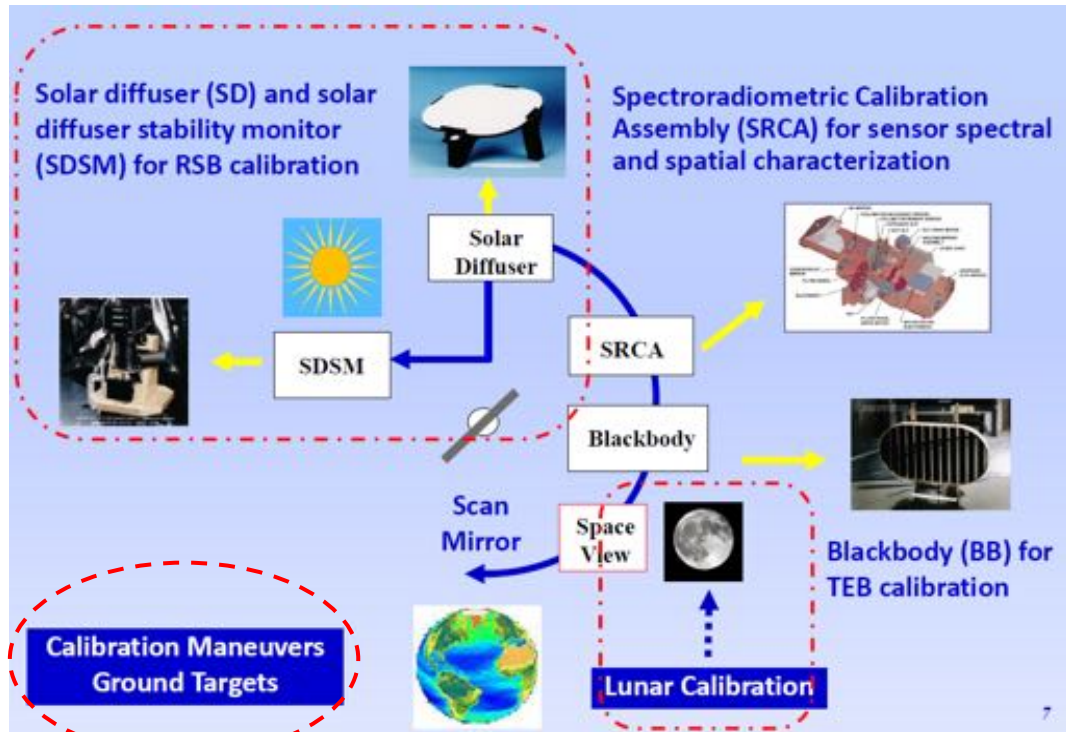
Instrument Status: N-20 VIIRS

Instrument Operations and OBC Functions – Normal

- No changes to instrument operational configuration since launch (A-side)
- No new noisy or inoperable detectors since launch
 - 1 noisy detector at launch (I3 D29)
- Single Board Computer (SBC) Lock-up (petulant mode): problem fixed
- Scan Sync Loss between RTA and HAM: 54 since launch (17 since last STM) – plus another event this morning



MODIS and VIIRS On-orbit Calibration



VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
M5	0.662 - 0.682	750	13 or 14	0.662 - 0.672 0.673 - 0.683	1000 1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250
M7	0.846 - 0.885	750	16 or 2	0.862 - 0.877 0.841 - 0.876	1000 250
M8	1.230 - 1.250	750	5	SAME	500
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000
I3	1.580 - 1.640	375	6	1.628 - 1.652	500
M10	1.580 - 1.640	750	6	1.628 - 1.652	500
M11	2.225 - 2.275	750	7	2.105 - 2.155	500
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000
M12	3.660 - 3.840	750	20	SAME	1000
M13	3.973 - 4.128	750	21 or 22	3.929 - 3.989 3.929 - 3.989	1000 1000
M14	8.400 - 8.700	750	29	SAME	1000
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000
I5	10.500 - 12.400	375	31 or 32	10.780 - 11.280 11.770 - 12.270	1000 1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000

Dual Gain: M1-M5, M7, M13

MODIS: bands 33-36

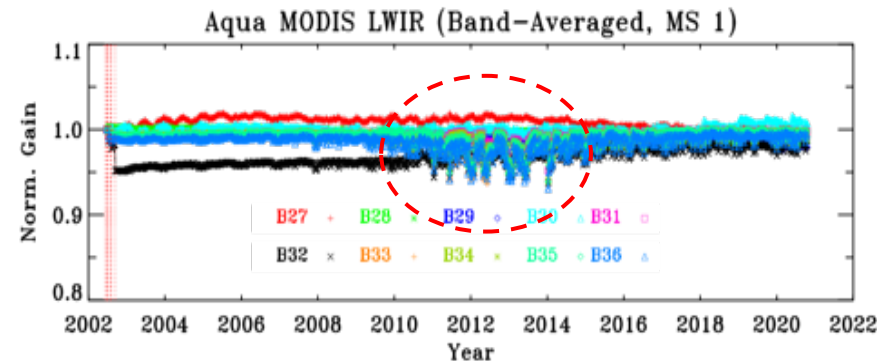
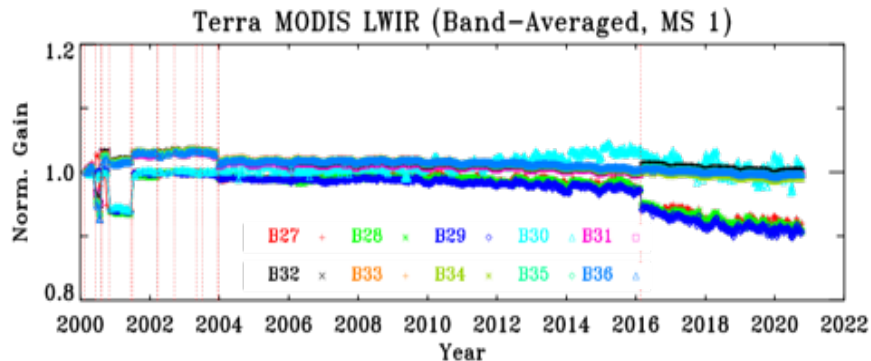
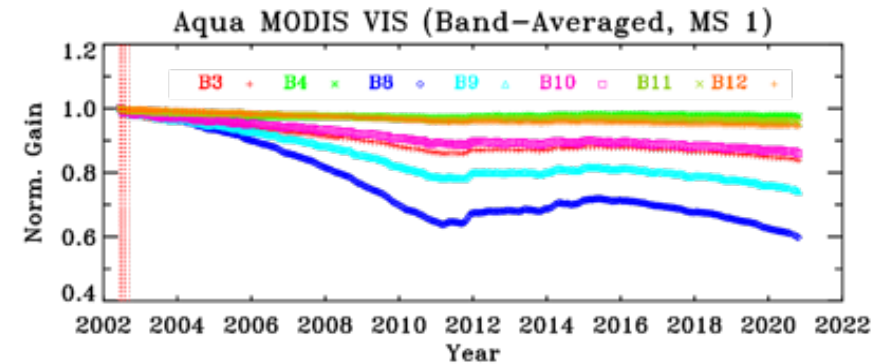
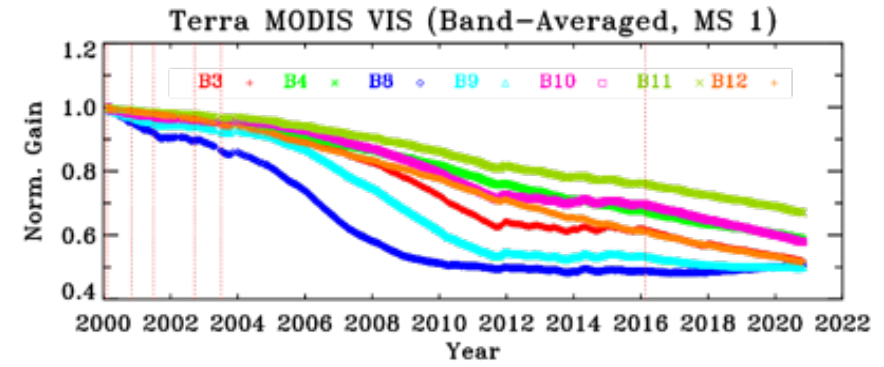
1 DNB
(0.5-0.9 μm)

14 RSB
(0.4-2.3 μm)

7 TEB
(3.7-12 μm)

Terra and Aqua MODIS Calibration and Performance

- **Radiometric**
 - Large changes in sensor response and RVS at short wavelengths
 - Large SD degradation at short wavelengths
- **Spatial and Spectral**
 - Band-to-band registration (BBR): stable since launch
 - Center wavelengths and bandwidths: changes are within 0.5 nm and 1.0 nm, respectively, for most VIS/NIR bands; relatively large changes for bands with broad bandwidths (bands 1, 17, 19)
 - LWIR PV (Terra) correction remains effective
- **Geolocation**
 - Stable and no changes since last STM



More Examples in
Backup Slides

S-NPP and N-20 VIIRS Calibration and Performance

- **Radiometric**

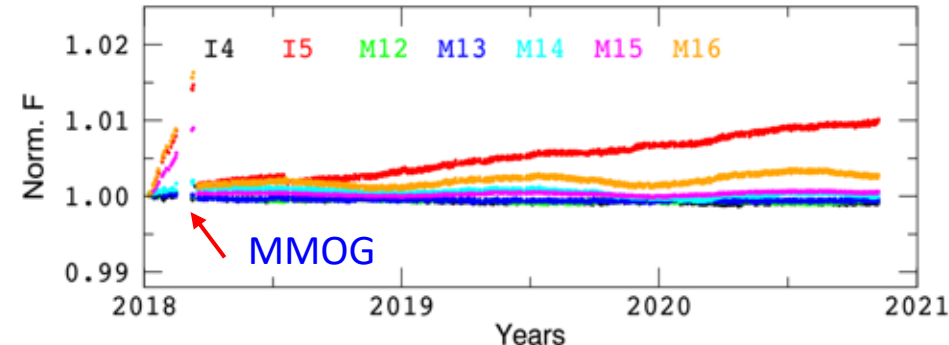
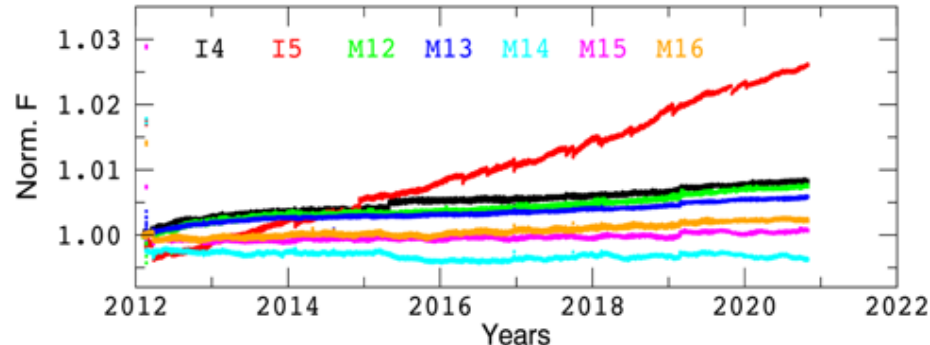
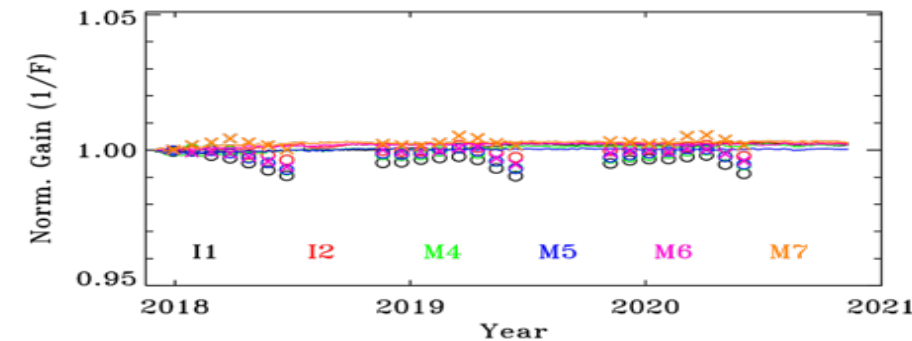
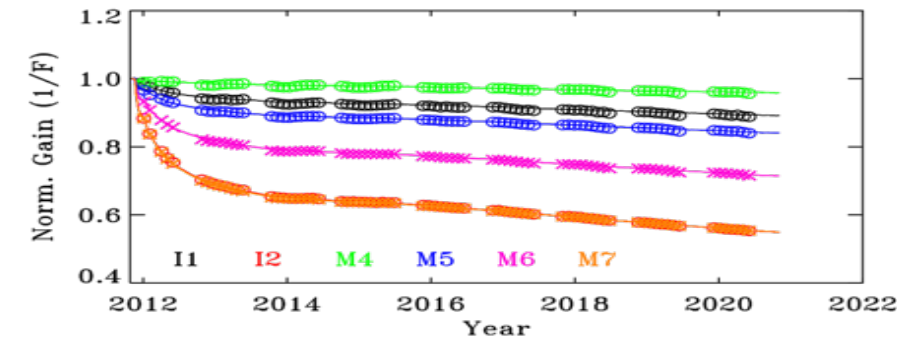
- Large response changes at NIR and SWIR wavelengths - a known issue for S-NPP; **extremely stable responses for N-20**
- Large SD degradation at short wavelengths
- TEB gains (N-20) has remain stable since the mid-mission outgassing (MMOG)

- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch
- S-NPP Modulated RSR: **very small changes in recent years**
- **Continued improvements for DNB stray light correction**

- **Geolocation**

- Small temporal variations will be corrected in C2



I5 gain has degraded about 3% for S-NPP and 1% for N-20

More Examples in Backup Slides

Current and Future Activities: Terra and Aqua MODIS

- Continue to monitor sensor performance and to derive and update calibration LUTs in support of C6 and C6.1 data production
- Prepare and finalize L1B C7 with algorithm enhancements, code changes, LUT generation, and testing – to deliver in late March, 2021 for science testing
- Continue to monitor and address crosstalk impact on Terra PV LWIR bands 27-30 (correction applied since C6.1)
- Monitor and update crosstalk correction for select TEB detectors (to be included in C7)
- Monitor and update Terra SWIR RVS LUT (to be included in C7)
- Support FOT for Terra and Aqua Constellation Exit Maneuver (CEM) activities
- Develop post-CEM calibration strategies in support of extended Terra and Aqua MODIS missions (use of OBC and lunar observations, vicarious calibration targets, and alternative approaches)
- Use new fitting approach for RSB RVS (single-site AOI fitting, site-independent approaches, DCC, inter-band calibration, ...)
- Improve uncertainty assessments for both RSB and TEB due to changes in C7.

Current and Future Activities: S-NPP and N-20 VIIRS

- Continue to monitor sensor performance and to derive and update calibration LUTs for mission-long reprocessing (S-NPP VIIRS C2 and N-20 VIIRS C2.1)
- Continue to improve fitting of S-NPP SD F-factor and lunar F-factor and prediction of future F-factor => reduce the LUT delivery frequency
- Support VIIRS L1B software updates - V3.1.0 released on Oct 28, 2020, including corrections in Quality Flags (both pixel and scan) and bug fixes for calibration during lunar view sector rotation
- Continue to monitor and correct detector-to-detector calibration differences (RSB)
- Continue to track potential changes in VIIRS RVS using the EV targets and DCC
- Develop and implement L1B uncertainty index
- Improve DNB calibration and stray light correction LUTs (use of ML for DNB stray light characterization)
- Develop strategies to address S-NPP and N-20 RSB calibration differences (a major challenge for generating consistent long-term data records)

Ongoing JPSS-2/3/4 VIIRS Pre-launch Calibration Activities

JPSS-2 VIIRS (launch in 2022)

- Ambient test completed in Aug 2016
- Sensor TVAC completed in Sept 2017
- Pre-Ship Review: March 28-29, 2018
- Delivery to NGSS; Aug 25 2020
- Spacecraft TVAC: 2021

JPSS-3 VIIRS (launch in 2026)

- Ambient test completed in Jan 2020
- TVAC test: Sept 2020 – Feb 2021

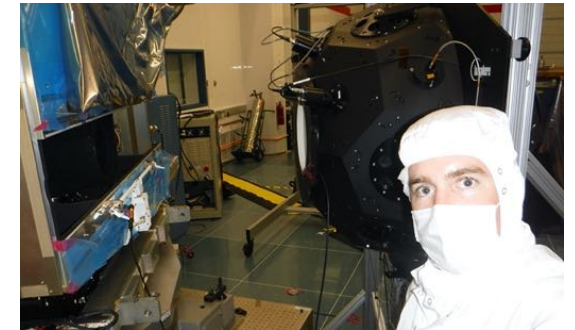
JPSS-4 VIIRS (launch in 2031)

- Ongoing I&T at sub-system/module level
- Ambient and TVAC tests: 2021 - 2022

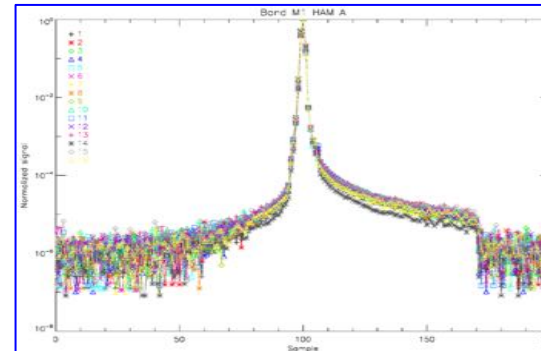
JPSS-2 VIIRS



GLAMR for J2 and J3 Test



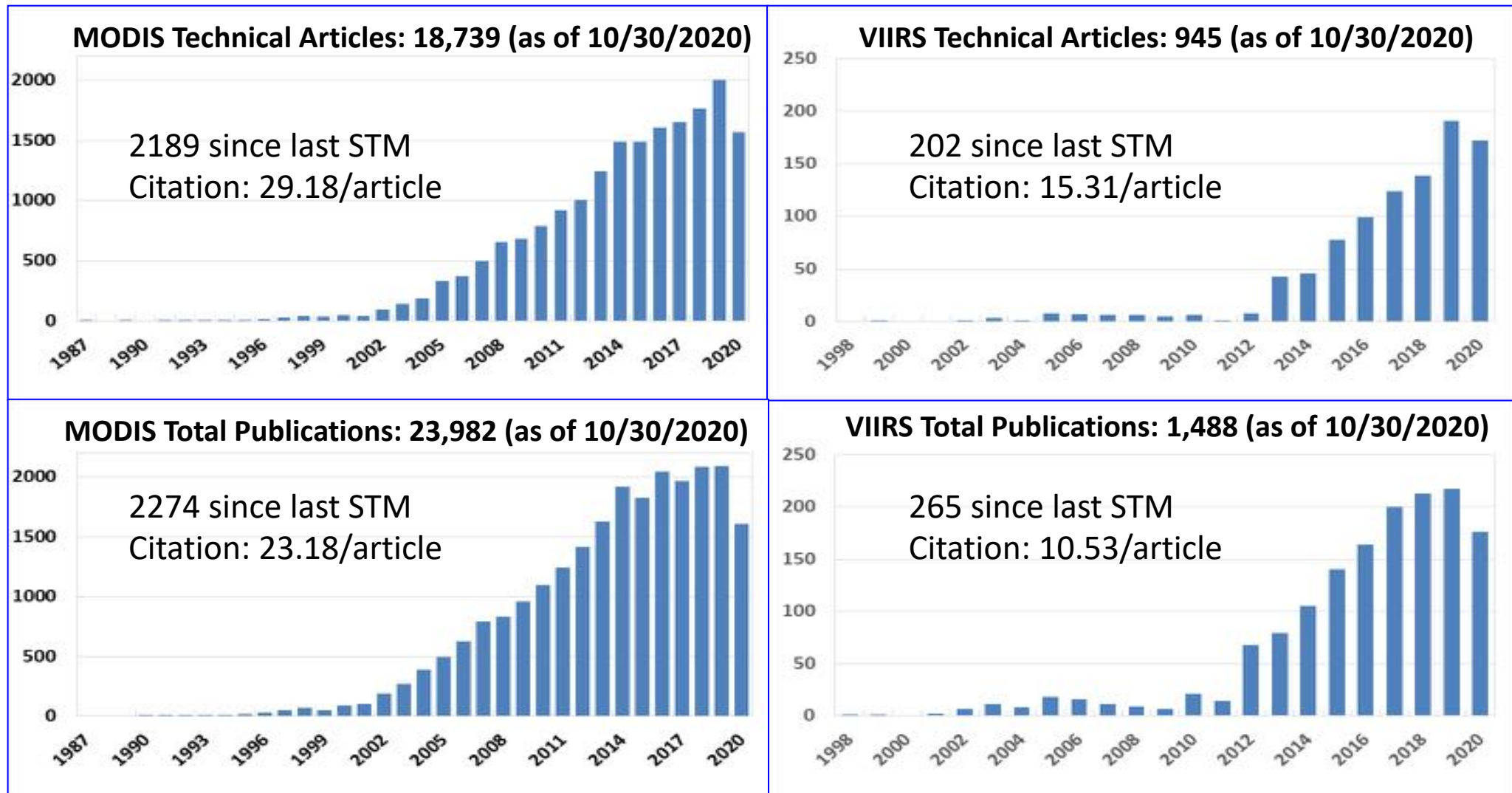
J3-VIIRS M1 NFR



MODIS and VIIRS Publications

MODIS: 18739 tech articles; 23982 tech article and proc. combined

VIIRS: 945 tech articles; 1488 tech article and proc. combined ([Web of Science](#))



Summary

- Both Terra (launched in 1999) and Aqua (launched in 2002) MODIS and their on-board calibrators [continue to operate and function normally](#)
- Both S-NPP (launched in 2011) and NOAA-20 (launched in 2017) VIIRS and their on-board calibrators [continue to operate and function normally](#)
- Steady progress being made for JPSS-2/3/4 VIIRS sensor development and testing
 - JPSS-2 VIIRS is ready for [spacecraft-level environment \(TVAC\) testing](#) (launch in 2022)
 - JPSS-3 VIIRS is under [sensor-level TVAC testing](#) (launch in 2026)
 - JPSS-4 VIIRS is under [I&T at sub-system/module level](#) (launch in 2031)
- Dedicated efforts have been made by the MCST and VCST
 - Characterize sensor performance (on-orbit and pre-launch)
 - Evaluate and address issues identified, including cross-sensor calibration differences (critical to consistent and long-term data records)
 - Support science data production and reprocessing ([MODIS C6/C6.1/C7 and VIIRS C2.0/C2.1](#))
 - Develop post-CEM (constellation exit maneuver) calibration strategies (Terra and Aqua)

Backup Slides

MODIS L1B Collection 7 Improvements

- In addition to Terra PV LWIR bands (in C6.1), crosstalk correction will be applied to select TEB detectors (4 in Terra MWIR bands and 10 in Aqua PV bands)
- Improved calibration algorithms to reduce mirror side striping in Aqua TEB and Terra LWIR PC bands (early mission only)
- Modified calibration approach to improve long-term stability in Terra PV LWIR bands (band 30)
- Offset coefficient (a_0) correction applied for bands 20 and 29 to reduce cold scene bias in Terra
- Methodology applied to reduce impact of polarization on Terra VIS band RVS characterization
- Improved RVS fitting approaches to be employed in C7
- Inter-band calibration (ratio-approach) to be applied for an improved RVS characterization of ocean bands (Terra MODIS bands 11 and 12)
- Terra SWIR band improvements include the use of band 25 as the sending band for crosstalk correction (already implemented in C6/C6.1 forward production) and a use of time-dependent RVS for bands 5 and 26

To be delivered for science testing in late March, 2021

VIIRS L1B (NASA) Collection 2 Improvements

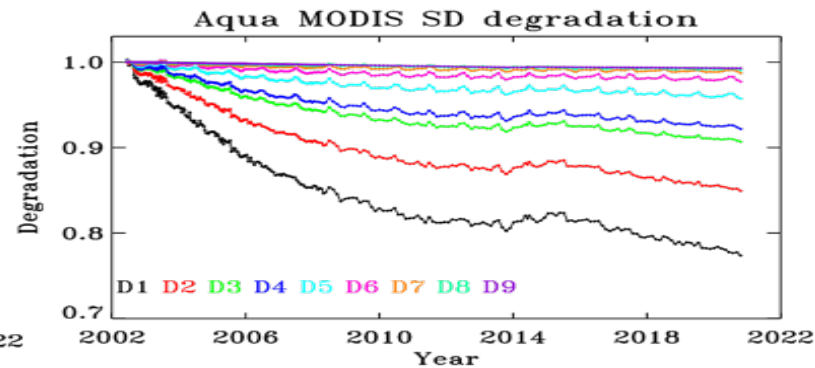
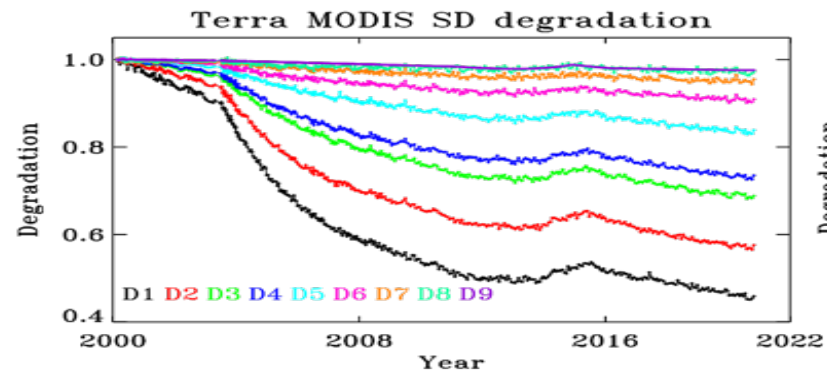
- **S-NPP**
 - Use of long-term lunar trending and positional (detector) dependent SD degradation
 - New delta-C LUT with correct temperature dependence; new scale integer table for M13
 - Improved fitting applied to lunar and SD F-factor ratios, which changes 0.8% and 0.3% for bands M1 and M2, respectively.
 - Improved fitting for better prediction of future F-factor => reduce the LUT delivery frequency
- **N-20**
 - Improved SD/SDSM screen transmission LUTs using yaw maneuver and regular on-orbit data
 - Adjustment of SD F-factors using lunar data (scaled from SNPP)
 - Added noisy detector flag in L1B for band I3, detector 29
 - Prelaunch RVS table updated and applied (July 2020) - impact on RSB is very small (< 0.1%); impact on TEB: < 1% for M14, 0.6% for M15, 0.4% for I5, and 0.3% for M16; impact on DNB is negligible
 - Improved fitting for better prediction of future F-factor => reduce the LUT delivery frequency

S-NPP VIIRS C2 started Nov 13, 2020, N-20 VIIRS C2.1 to be started soon

MODIS and VIIRS SD Degradation

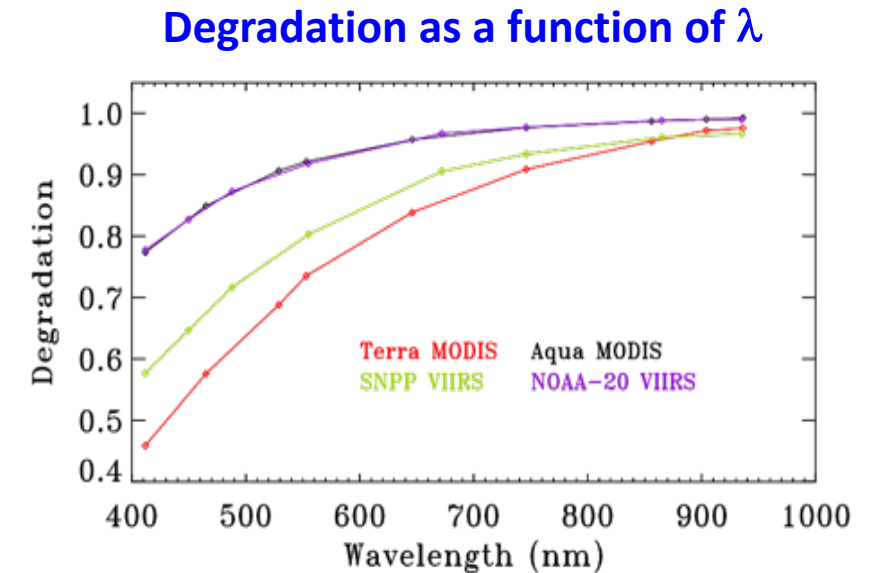
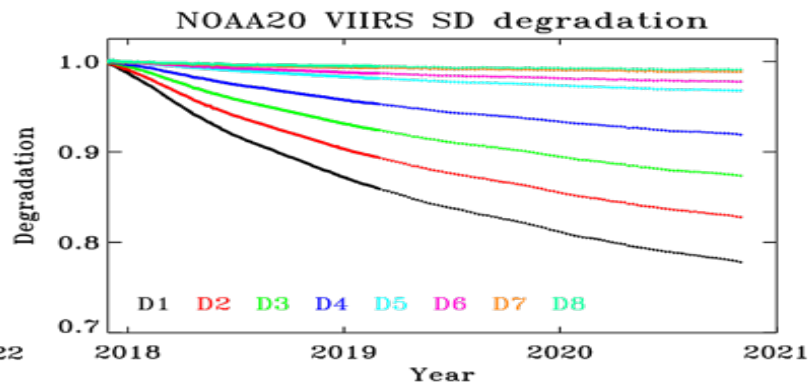
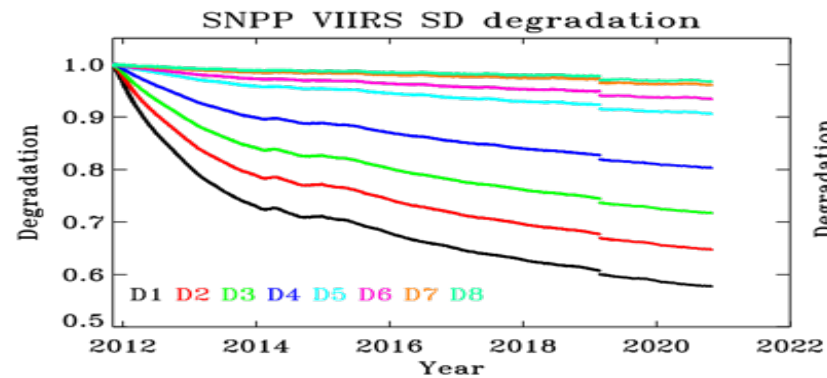
Terra MODIS

Aqua MODIS



S-NPP VIIRS

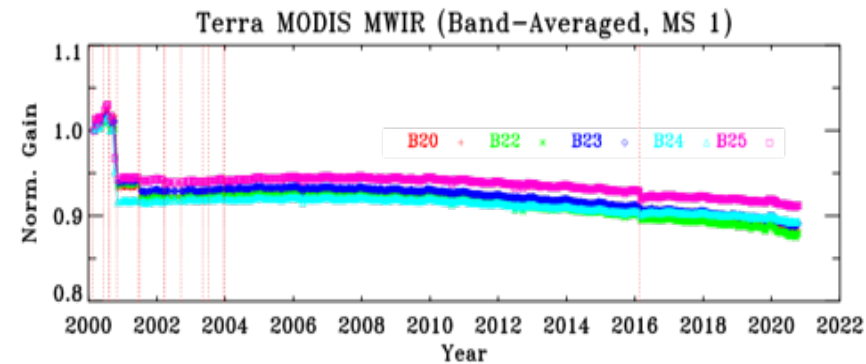
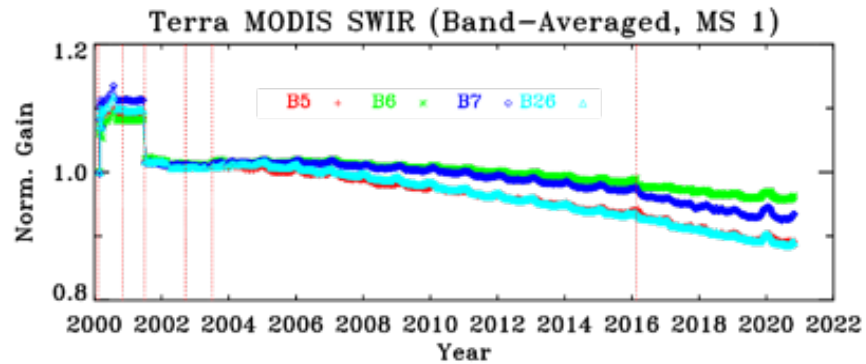
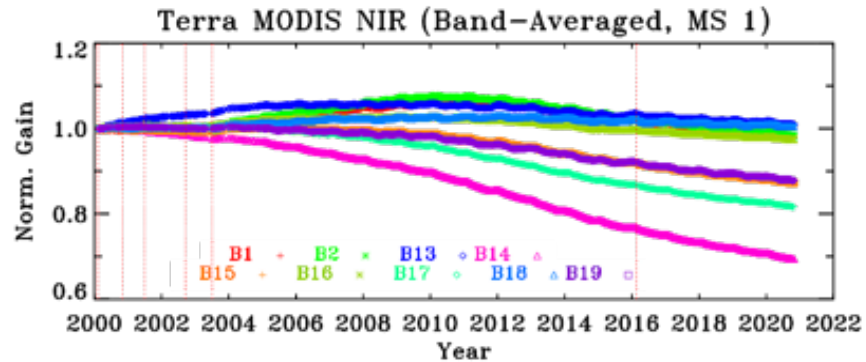
N-20 VIIRS



SDSM Detector	D1	D2	D3	D4	D5	D6	D7	D8	D9
MODIS (μm)	0.412	0.466	0.530	0.554	0.646	0.747	0.857	0.904	0.936
VIIRS (μm)	0.412	0.445	0.488	0.555	0.672	0.746	0.865	0.935	

MODIS Radiometric Response (Gain) Trending

Terra MODIS

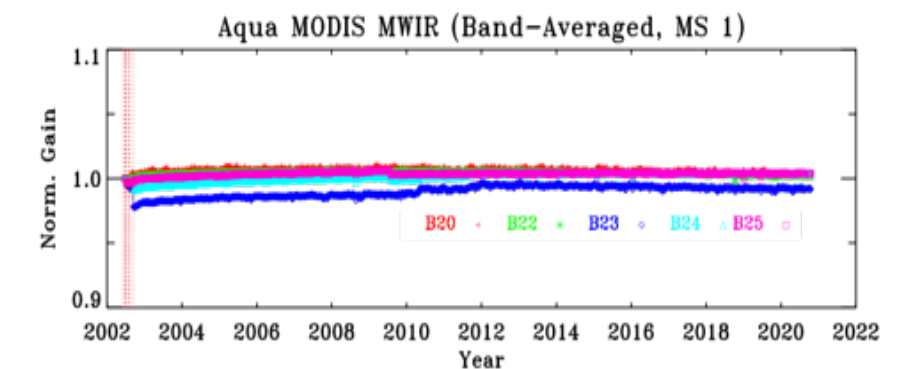
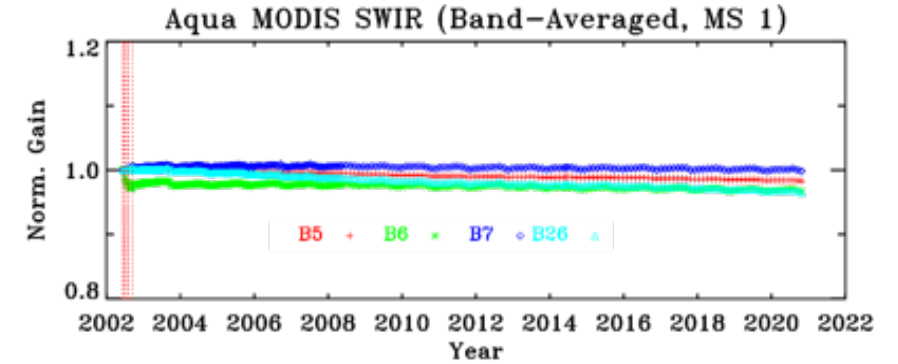
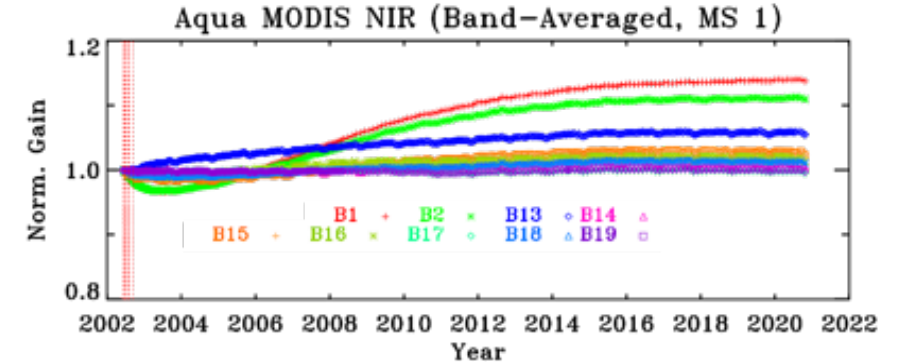


NIR bands

SWIR bands

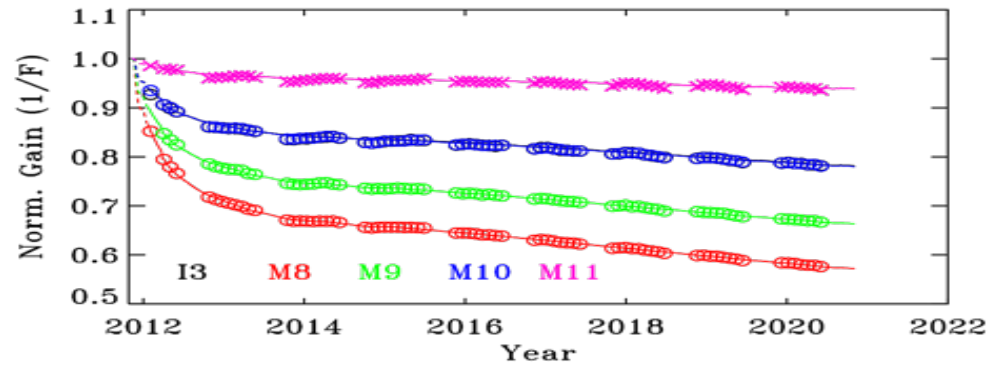
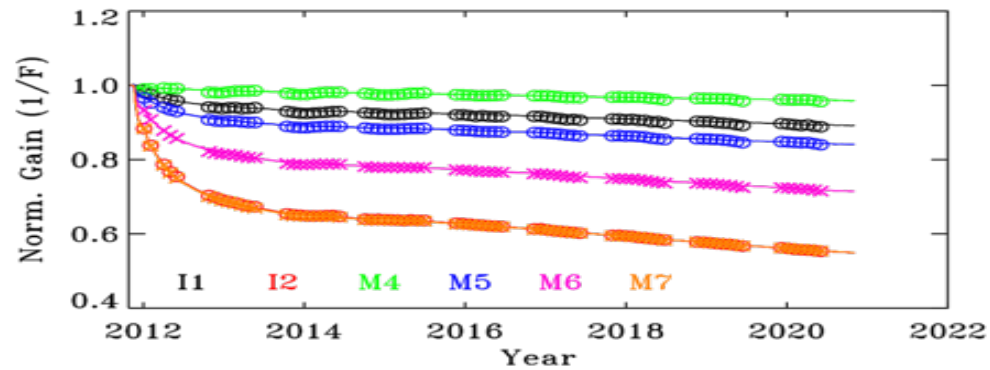
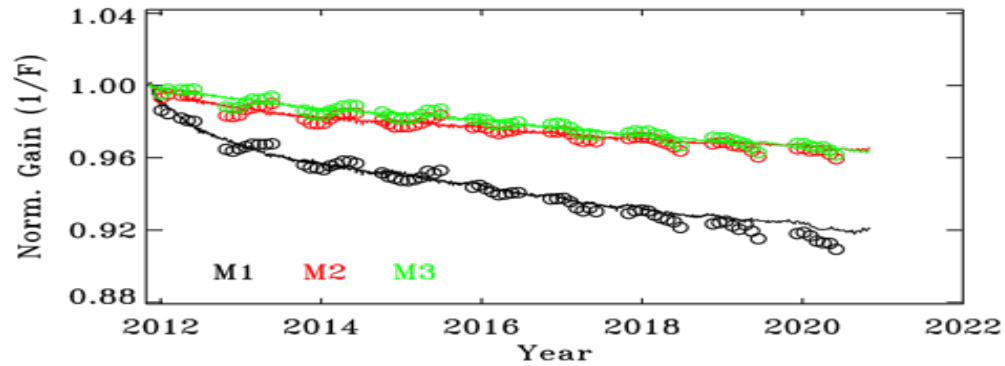
MWIR bands

Aqua MODIS

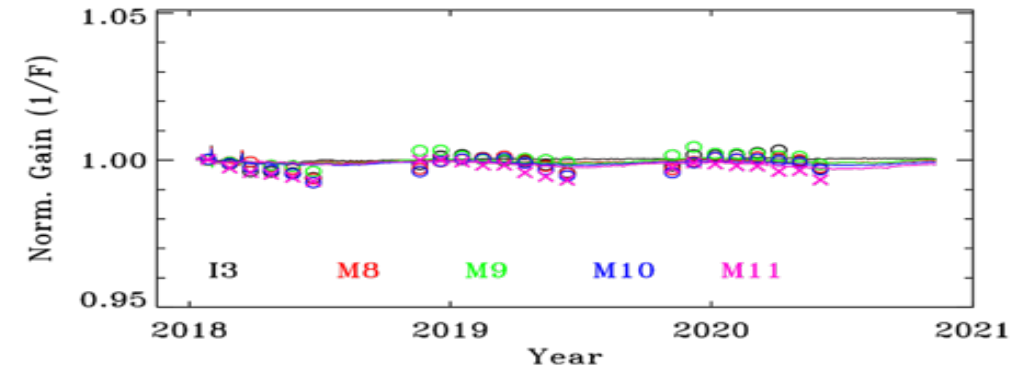
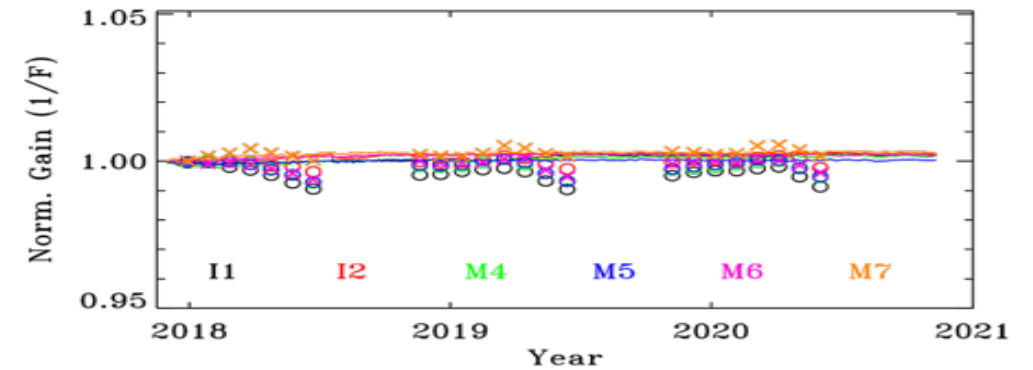
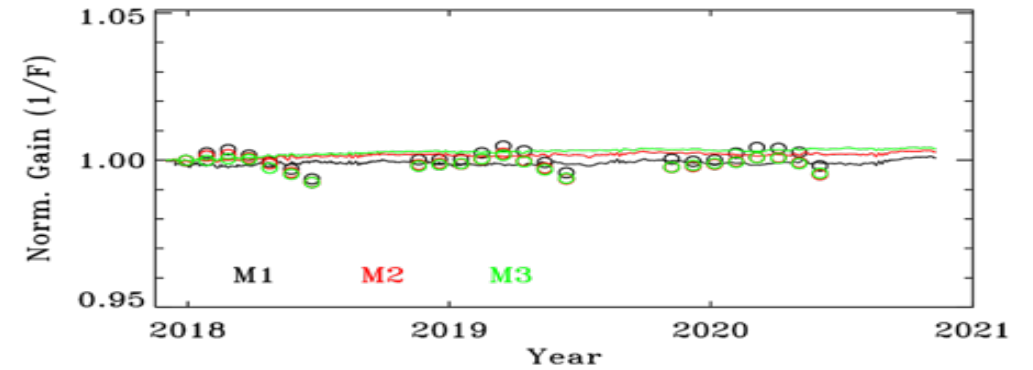


VIIRS Radiometric Response (Gain) Trending - RSB

S-NPP VIIRS

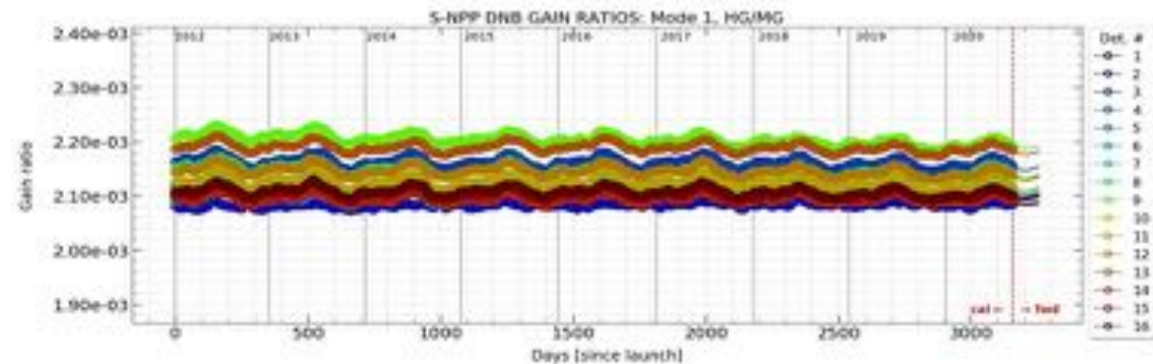
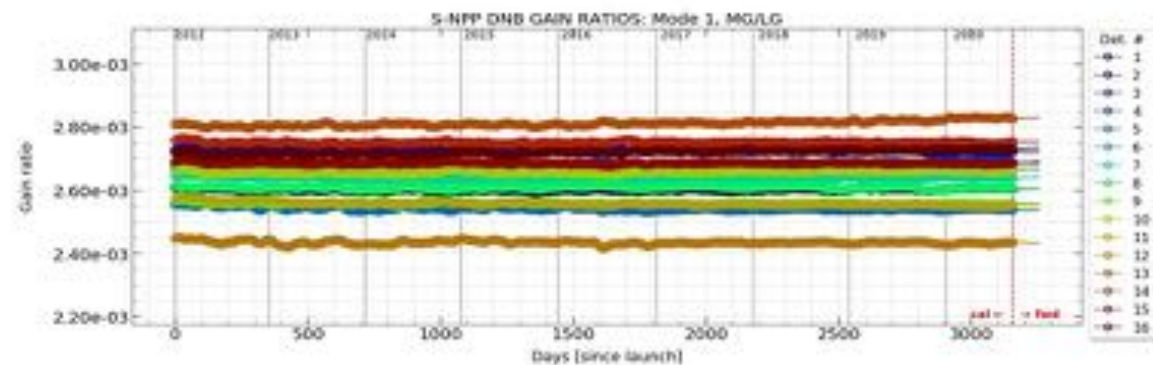
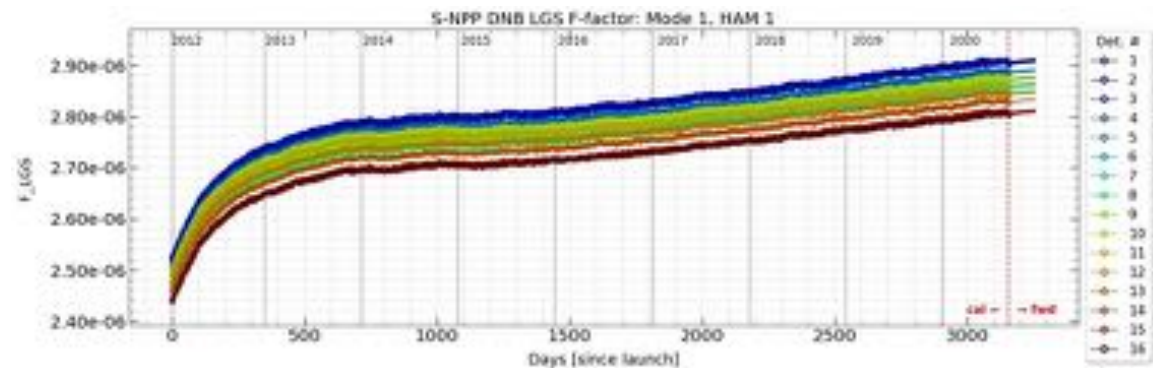


N-20 VIIRS

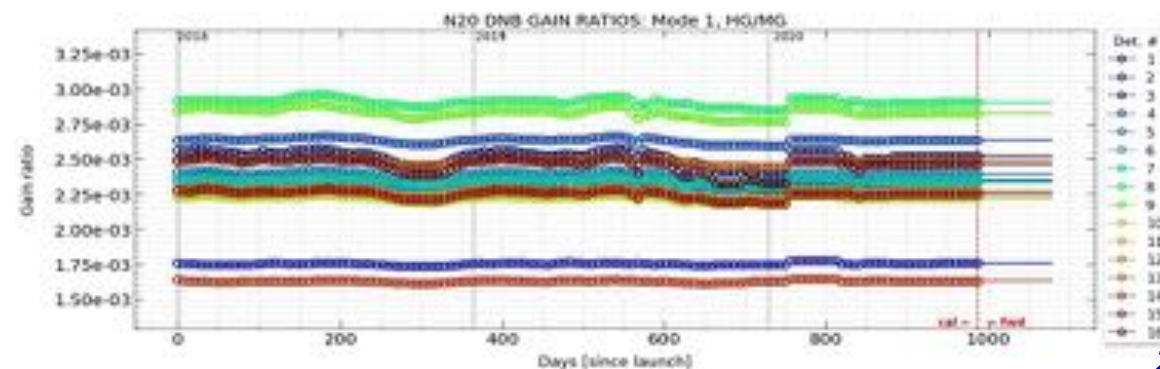
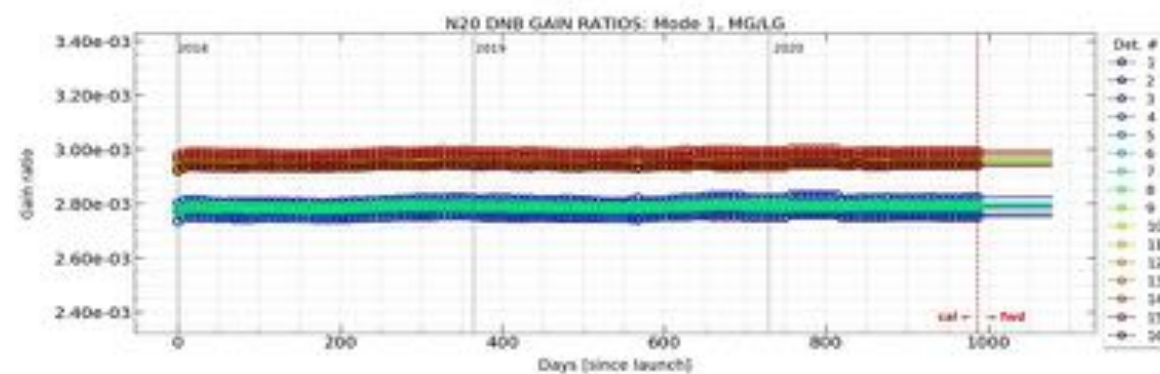
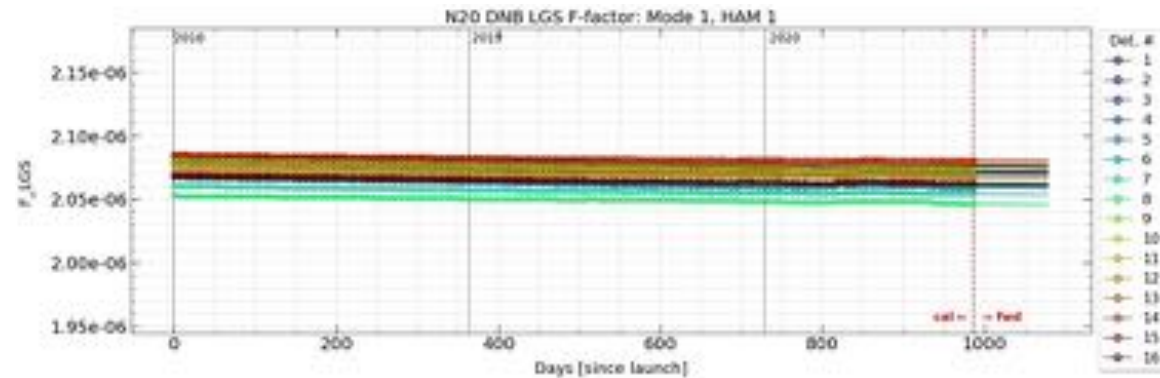


VIIRS DNB F-factor (LGS) and Gain Ratio Trending

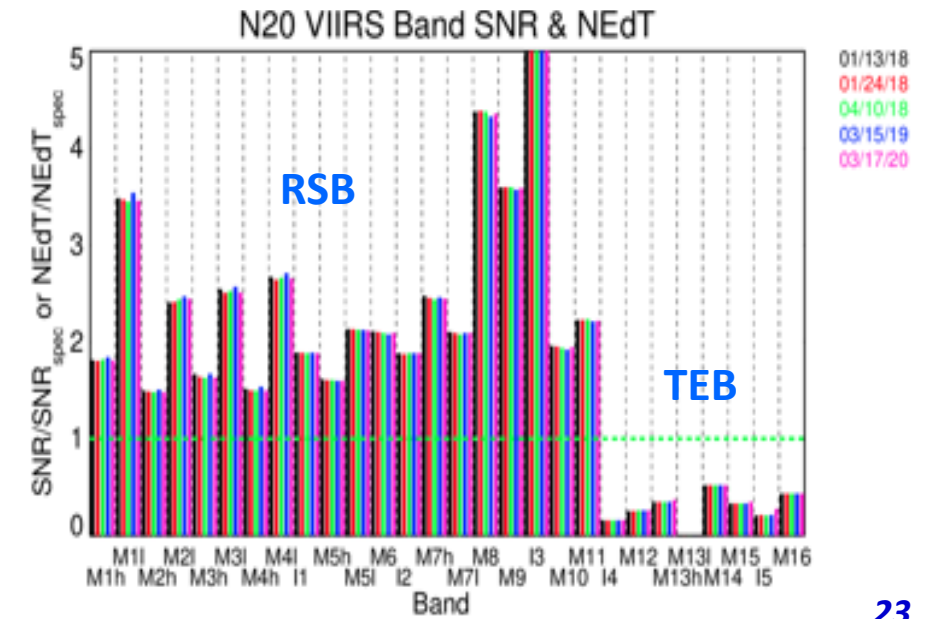
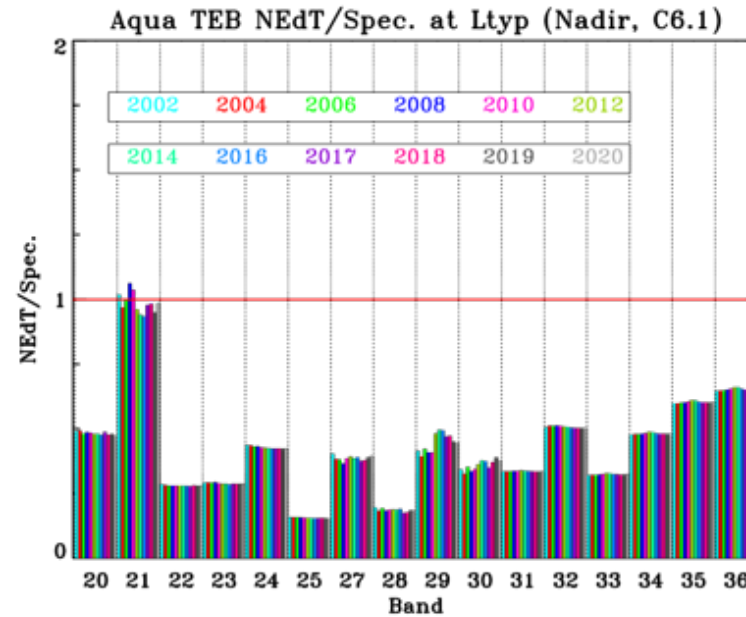
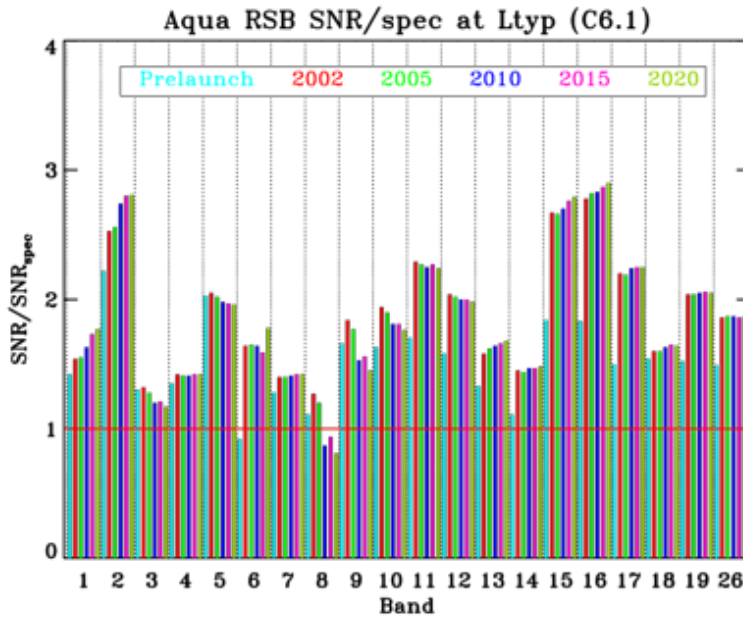
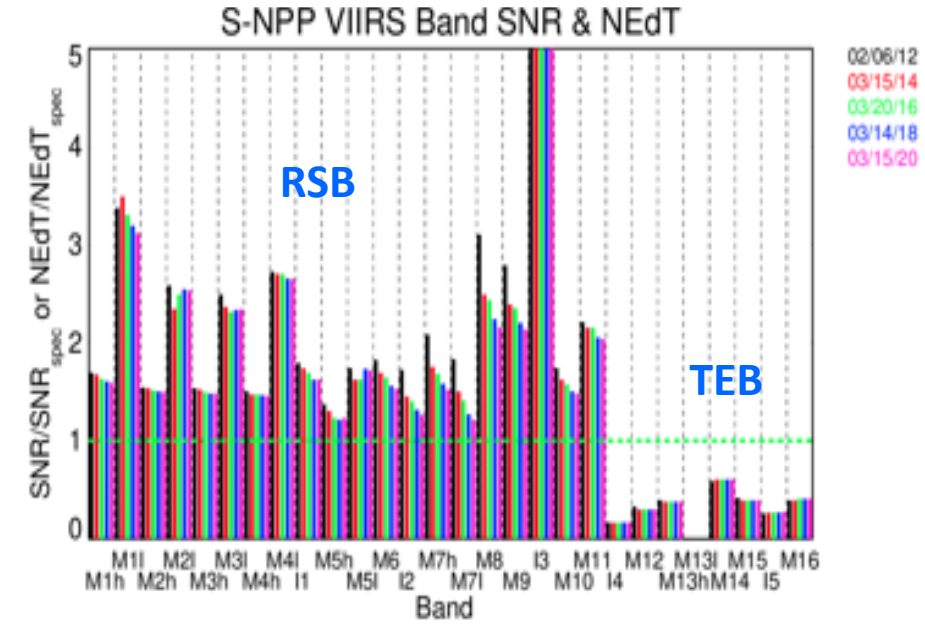
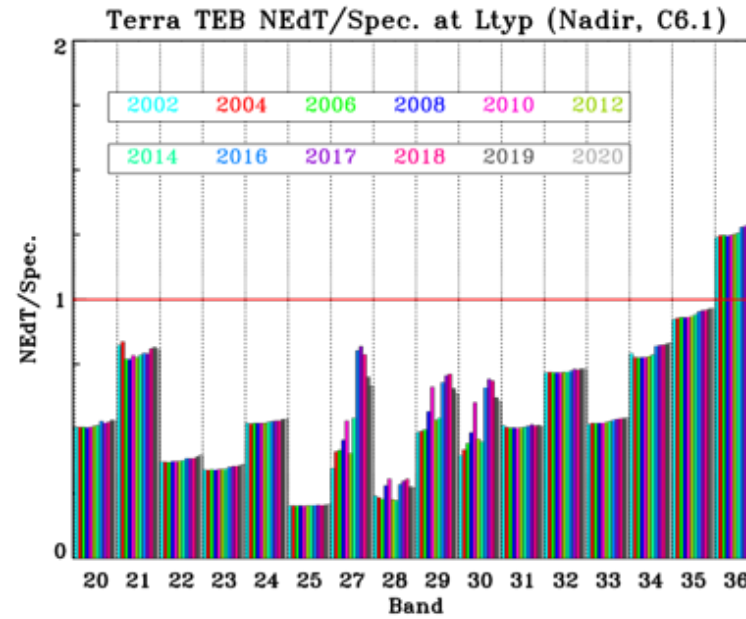
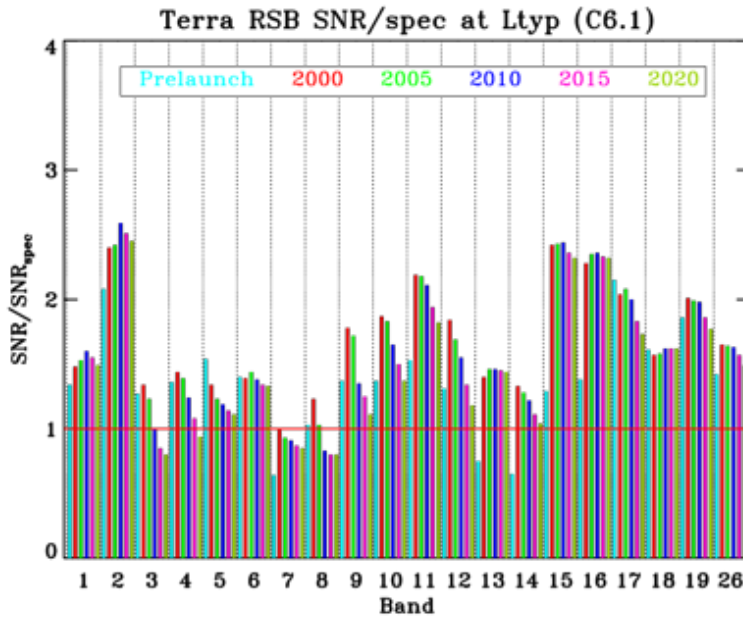
S-NPP VIIRS



N-20 VIIRS



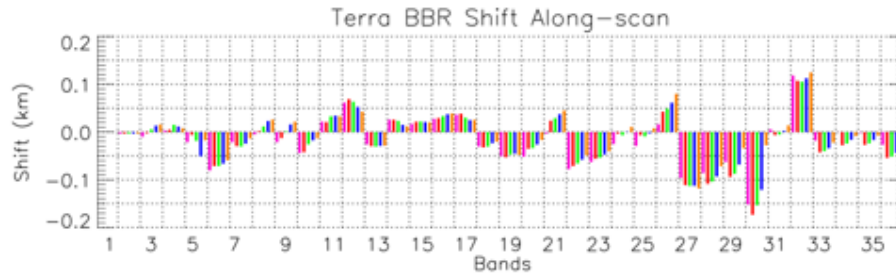
MODIS and VIIRS SNR and NEdT (comparison with Spec)



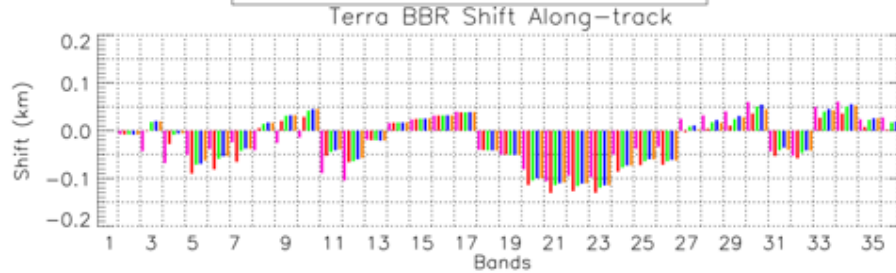
MODIS Spatial and Spectral Characterization

Terra MODIS

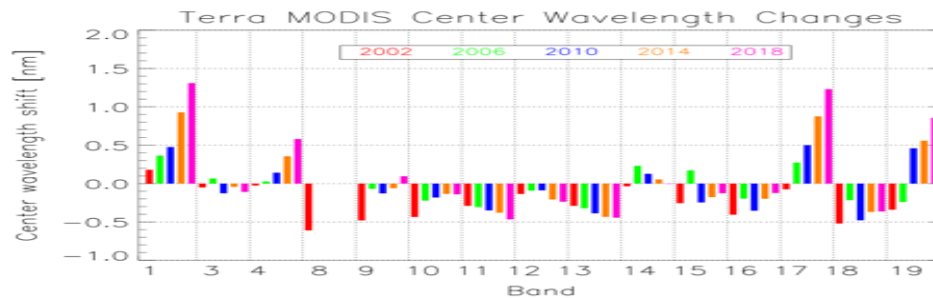
Along-scan BBR



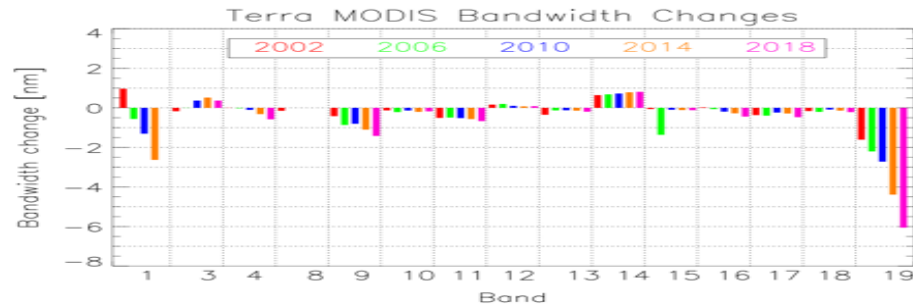
Along-track BBR



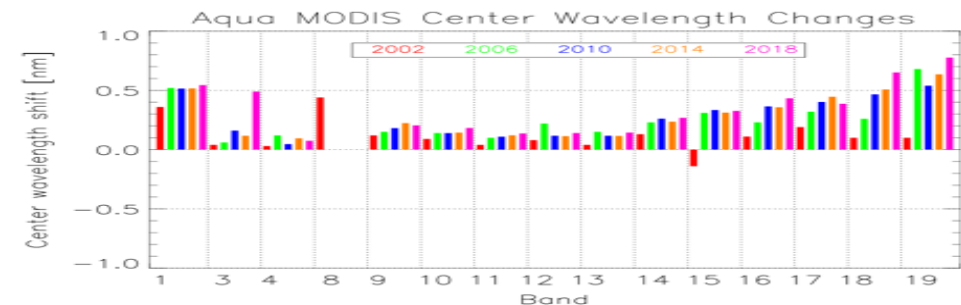
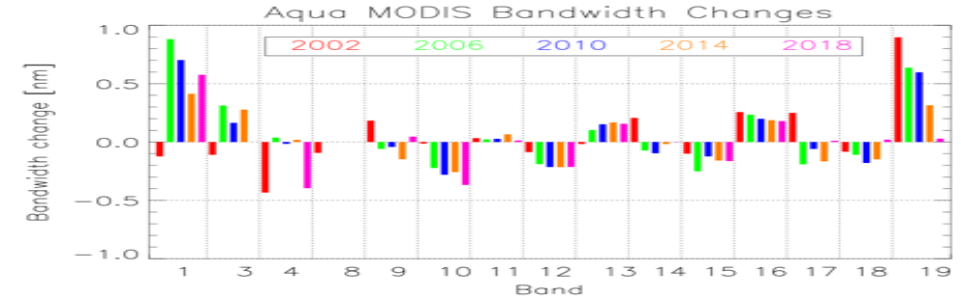
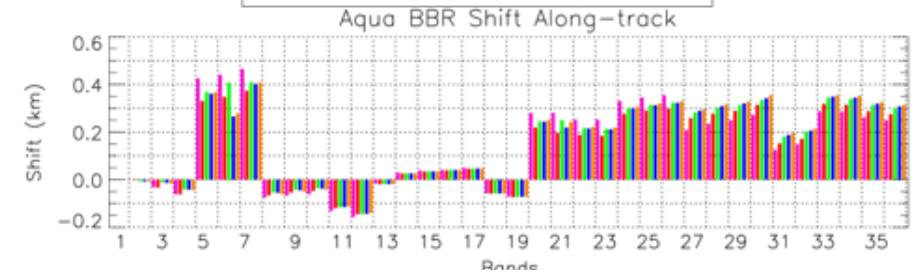
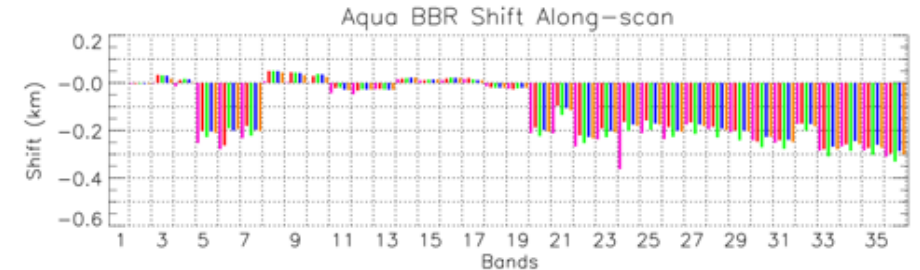
Changes in CW



Changes in BW



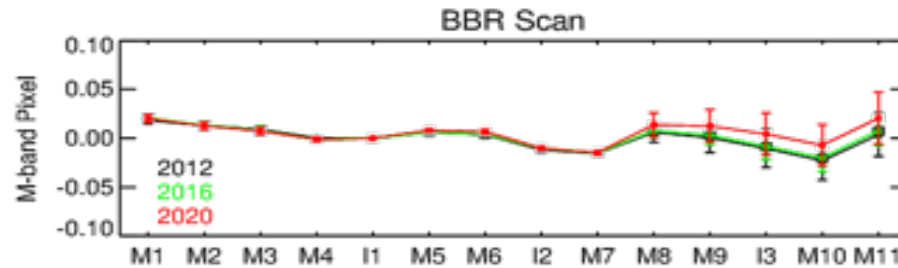
Aqua MODIS



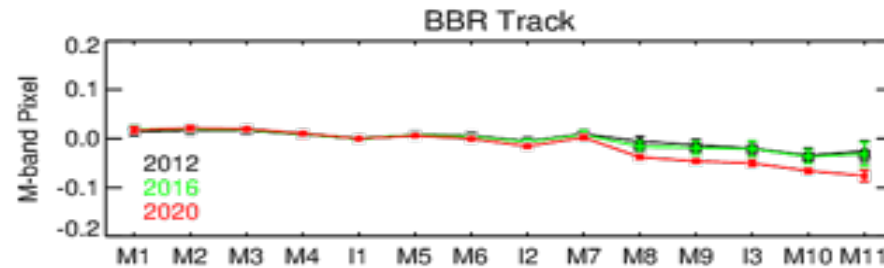
VIIRS Spatial and Spectral Characterization

S-NPP VIIRS

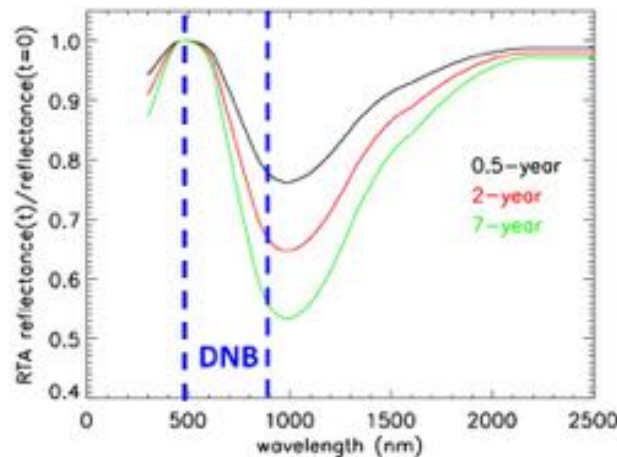
Along-scan BBR



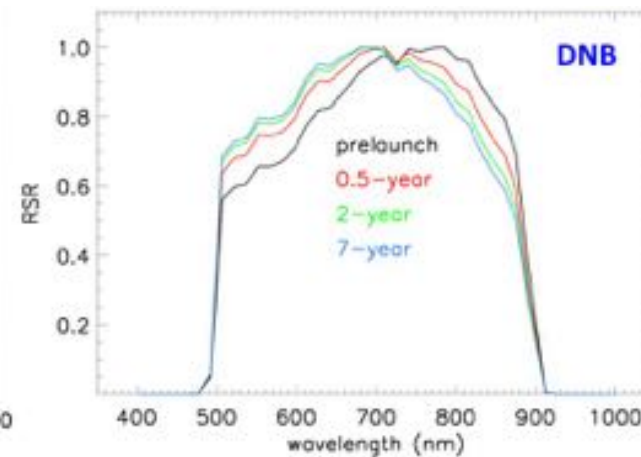
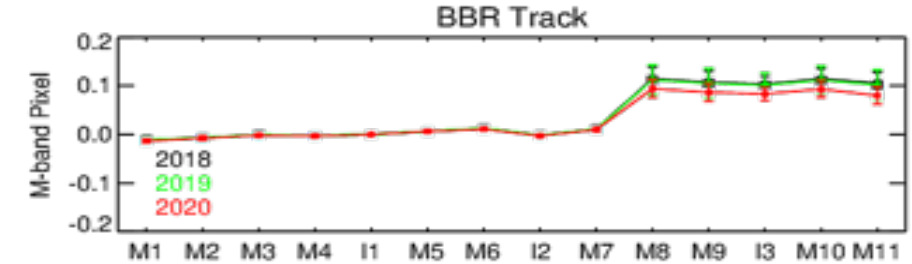
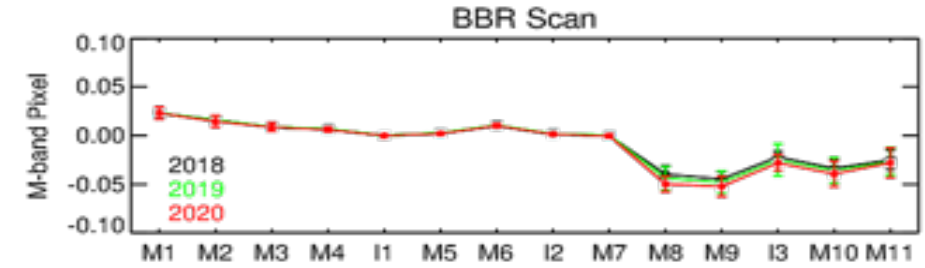
Along-track BBR



Modulated RSR
(S-NPP only)



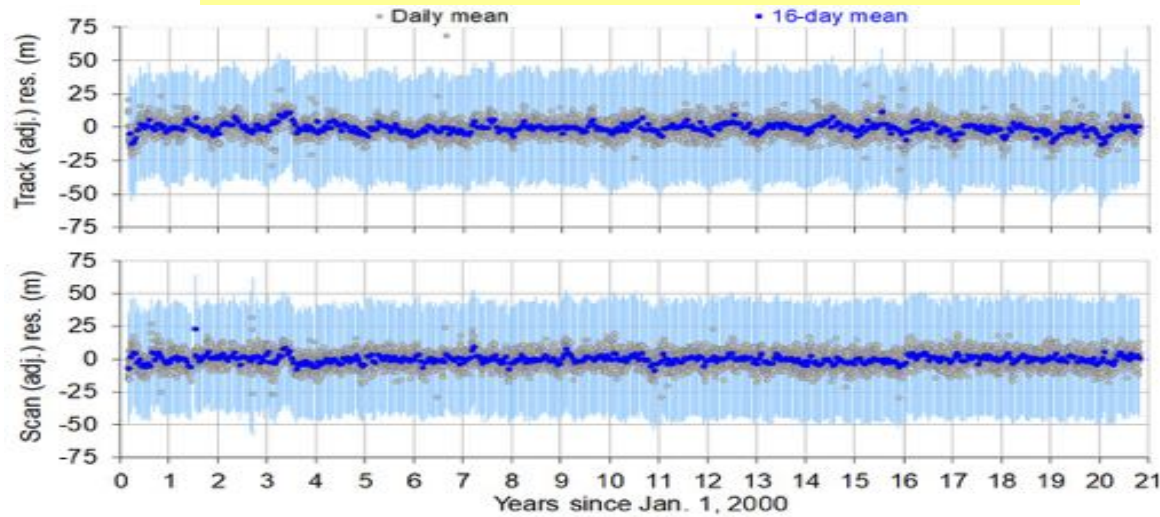
N-20 VIIRS



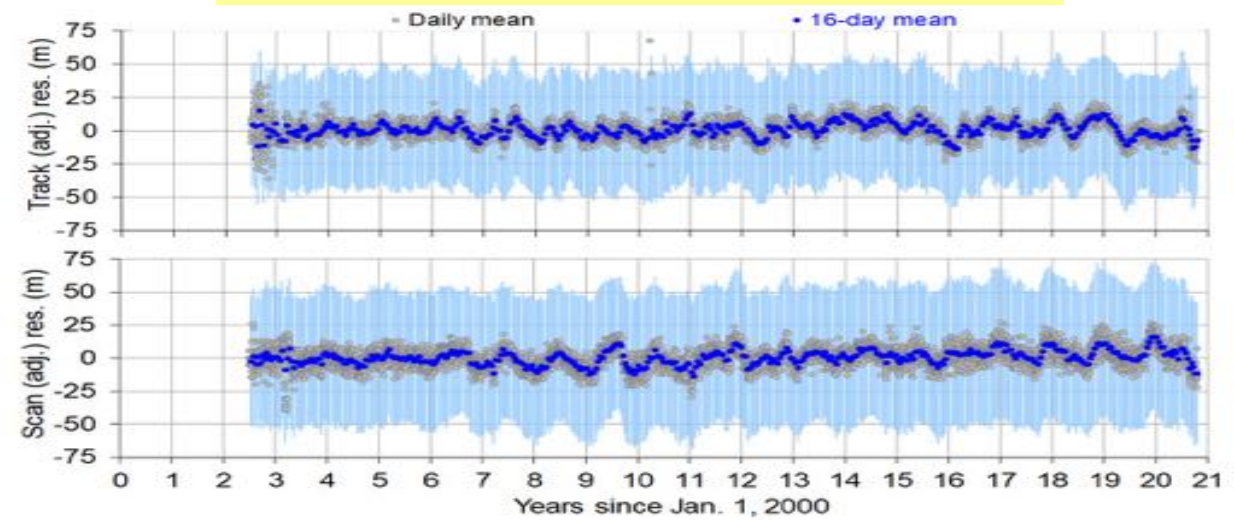
- Wavelength dependent optics degradation => modulated RSR
- Impact depends on spectral band wavelength, bandwidth, and OOB
- Changes in modulated RSR has been extremely small in recent years

MODIS and VIIRS Geolocation

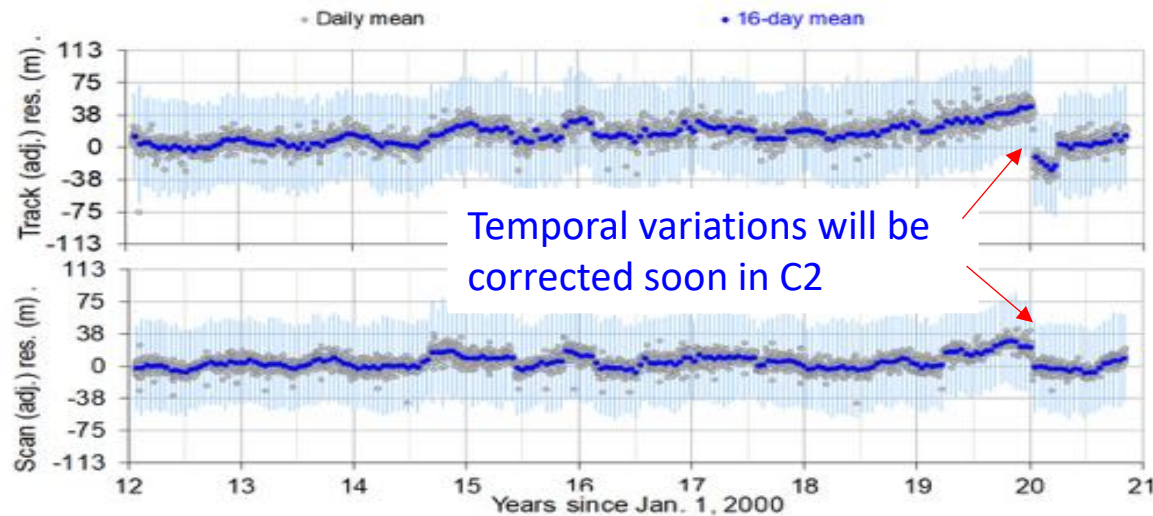
Track: 43 m; Scan: 45 m (Terra C6.1)



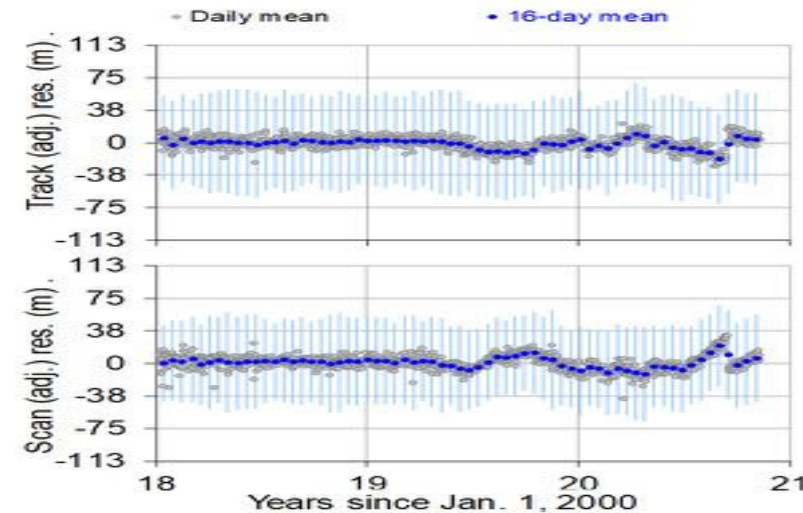
Track: 46 m; Scan: 54 m (Aqua C6.1)



Track: 59 m; Scan: 52 m (S-NPP C1.1)



Track: 55 m; Scan: 49 m (N-20 C2)



Lin et al., 19 Nov 2020